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**AIRBORNE PARTICLE MONITORING BY  
ELECTROSTATIC PRECIPITATION**

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ABSTRACT

For qualitative analysis of atmospheric particulates by microscopy, the sampling device should preserve the particles in the state existing at the moment of capture. A collector is described that uses electrostatic precipitation to capture and disperse specimens on various substrates for direct insertion into microscopes. Sampling runs in various atmospheres are described. Micrographs are presented to show particle morphology and distribution on the substrates. Chemical identification by x-ray energy probe and electron diffraction is illustrated.

Qualitative analysis of airborne particles smaller than five microns requires careful collection and definition of the object of interest. The smaller the particle, the more physical forces act upon it to obscure its individuality. Such particles group and regroup constantly, making precise definition of a "particle" difficult in air pollution matters.

Analysis of abatement equipment performance must deal with this difficulty. Unfortunately, contemporary sampling systems often add to the confusion, whereby, particles collected for analysis do not necessarily represent a true "sample" of the atmosphere under study.

For this reason, the device described below was developed so that a sample could be extracted and deposited onto a substrate that could then be inserted directly into a microscope. Subsequent physical alterations, often a result of the transfer from collection device through intermediate steps, are eliminated. All particles are preserved in the size and shape prevailing at the sampling location at the instant of capture.

Description

Collection substrates can be standard microscope

slides, carbon planchets, or film coated specimen grids. Substrates are inserted between two electrodes. A high voltage source is energized to create an electrical field between the electrodes. Airborne particles moving thru the field receive a charge and are attracted to and dispersed on the oppositely charged collecting surface. The surfaces are then ready for examination and analysis in the electron or light microscope without further preparation.

Control parameters include operating mode, air flow, and electrostatic field. Two optional modes of operation are provided. In the continuous mode, the electrostatic field is energized continuously as air is drawn over the collecting surface. In the pulsing mode, an air sample is drawn in, the flow is stopped, and the field is energized. Timing cams provide a selection of on-off intervals. The number of cycle repeats or the length of a continuous run are controlled by a time clock. Air flow is regulated by the blower speed; the maximum flow being approximately 85 liters per minute. Field energy is regulated by changing the electrode gap.

The instrument is powered by a 12 volt acid-gel rechargeable battery for which a plug-in 110 volt recharger is provided. High voltage is generated by a power source with a maximum output of 5000 volts. The high voltage circuit is securely insulated from the surrounding equipment, however, the total power output is only 500 milliwatts.

An internal light is provided for viewing the electrode adjustment and the specimen deposition. A rotatable 90° elbow is provided to direct the air intake and control variations caused by surrounding air movement.

A secondary collection system is included to provide a simultaneous quantitative record of the total particulates in the atmosphere being sampled by the precipitator. Air is drawn thru a pre-weighed Millipore filter secured in a cassette which can be closed and transferred to a laboratory for postweighing without risk of contamination.

#### Performance Evaluation

Verification that the test specimens include representatives of all particles in a sampled atmosphere requires that the identity of all particulates in that atmosphere be known. This is never the case in investigative sampling. Although verification can be accomplished by laboratory controlled runs using known inputs, the experiments must include a sufficiently

wide range of materials and environmental conditions to satisfy all situations.

As an alternative to such an extensive program, sampling runs were made under various circumstances to show the capabilities of the equipment.

Run No. 36: The atmosphere was sampled on an autumn day in a semi-rural area where vegetation and earth dust particles predominate. The collector was at ground level with the intake port pointed downwind. Wind velocity was five mph and temperature was 10° C.

The collection surface was a microscope slide glass and the gap between the glass and the upper electrode was a 3.5 mm. The duration of the run was 60 minutes in the pulsing mode. Particle distribution over a three mm<sup>2</sup> area is shown in Figure 1.



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Figure 1

Run No. 34: The location of the collector was at ground level on the shoulder of an asphalt, two lane road carrying continuous car and truck traffic. The intake port pointed across the road. There was no wind and the temperature was 20° C.

The collection surface was a pyrolytic graphite planchet and the gap between the planchet and the upper electrode was 4.7 mm. The duration of the run was 115 minutes in pulsing mode.

Particles collected are shown in scanning electron micrographs Figures 2 and 3. As would be expected, the particles are predominately organic (petroleum hydrocarbons and vegetation) and include many metallic

particles, eg. aluminum, iron, magnesium.

The x-ray energy probe read-out that identifies chemical elements is shown in Figure 4. The peaks, reading from the left, identify magnesium, aluminum, silicon, sulfur, chlorine, potassium, calcium, titanium and iron. All of these elements are in the single soil particle on the left in Figure 3, the major element being silicon.



Figure 2



Figure 3

0 60SEC 295351MT  
VS:2500 HS: 50EV/CM

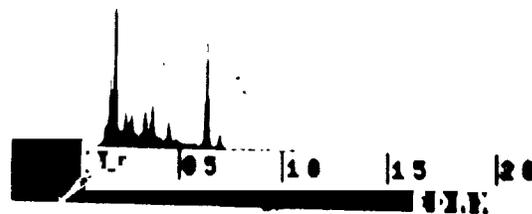


Figure 4

Run No. 35: The collector was placed two feet away from an automobile exhaust pipe expelling wet vapor from a warm engine (1968 Chevrolet 307). The collection surface was a pyrolytic graphite planchet and the electrode gap was 2.7 mm. Duration of the run was 2 minutes in pulsing mode.

Particles collected are shown in SEM micrographs, Figures 5 and 6. The large sphere in Figure 5 is a hydrocarbon particle encasing a lead particle. The irregular shaped particles in Figure 6 are calcium sulfate.



Figure 5



Figure 6

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Run No. 38: In this case, smoke from burning magnesium was directed into the collector intake in a laboratory controlled experiment. The collection surfaces were formvar film covered grids which were subsequently examined on a transmission electron microscope. The electrode gap was 2.5 mm. Two runs were made of 2 minutes duration, one with continuous and one with pulsing mode. Distribution results are compared in Figure 7 and 8 respectively. They are not significantly different.



Figure 7

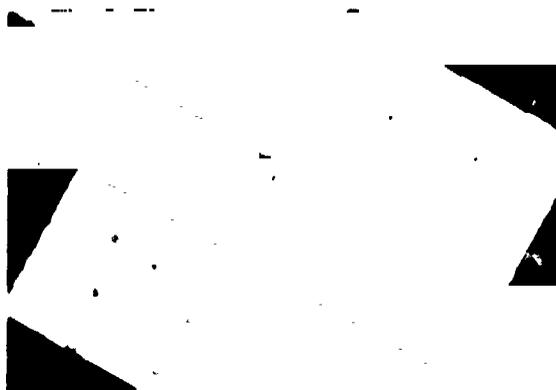


Figure 8

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Figure 9 is a transmission electron micrograph illustrating the size range of the particles dispersed.



Figure 9

Run No. 39: Collection was made in the same location as Run No. 34 on formvar covered grids for examination by a transmission electron microscope. The inorganic chemical compounds collected were identified by electron diffraction. The pattern shown in Figure 10 identifies a particle of aluminum silicate ( $\text{Al Si}_2 \text{O}_8 (\text{OH})_2$ ).

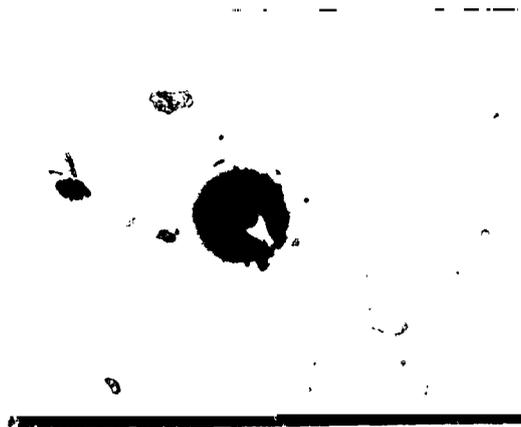


Figure 10

#### SUMMARY

The principle advantage of particle collection by electrostatic precipitation is the preservation of particles in the condition existing at the moment of capture. This device has the additional advantage of dispersing particles directly onto a choice of collecting surfaces thereby enabling optional selection of the microscope equipment to be used.

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